SECTION 03420

PLANT - PRECAST STRUCTURAL

1 GENERAL

1.1 SUMMARY (NOT APPLICABLE)

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

ASTM A C150 or AASHTO	(1991) Portland Cement
ASTM C283	(1991) Low and intermediate tensile strength, carbon steel plates, shapes and bars
ASTM A 615	(1991) Deformed and plain billet steel bars for concrete reinforcement
ASTM C39	(1990) Compressive strength of cylindrical concrete specimen
ASTM C31	(1990) Making and curing concrete test specimens in the field
AASHTO T27	(1991) Sieve analysis of fine and coarse aggregates
AASHTO T236	(1991) Direct shear test of soils under consolidated rained conditions
AASHTO T99	(1990) Moisture-density relations of soils using a 5.5 lb (2.5kg) rammer and a 12 (305mm) drop

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with SECTION 01300 SUBMITTALS:

SD-04, Drawings

Spread Footings Layout and Details; GA

Drawings shall include dimensions and overall plan layouts of footings based on in-situ conditions. They shall also include the number, size, type, and locations of all reinforcing steel bars in the footings.

SD-13, Certificates

Steel Panels; FIO

Certificates of compliance stating that the steel components inside the TechSpan™ precast element and the element fabrication conform to the requirements specified.

SD-20, Construction Methods and Procedures

TechSpan™ Arch System; FIO

Technical description of the materials, equipment, methods, procedures, and construction sequence to be used in constructing the TechSpan arch system, Procedures shall generally conform to those provided by the patent holder.

1.4 STORAGE

TechSpan precast elements shall be stored on wooden bearers out of contact with the ground with a slope of 1:100 along the precast element length to prevent accumulation of water.

2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

The Contractor shall make his own arrangements to purchase the materials covered by this section of the specifications including concrete arch segments, joint materials, impermeable geomembrane, and all necessary incidentals from The Reinforced Earth Company (RECO), 8614 Westwood Center Drive, Suite 1100, Vienna, Virginia 22182 (Phone: 703-821-1175). The TechSpan™ system is protected by the U.S. Patent Number 4,826,639, application number 5212.

2.2 PRECAST CONCRETE ARCH SYSTEM

2.2.1 Concrete Reinforcement

ASTM A615 with 60,000 psi minimum yield strength.

2.2.2 Concrete

1. Cement shall be Types I, II, or III, 3.0-6.0% air entrainment, and shall conform to the requirements of ASTM C150-86.

2. Concrete shall have a compressive strength at 28 days in accordance with Section 2.2.9.

3. Retarding or accelerating agents, or any additive containing chloride shall not be used without approval of RECO.

4. Concrete cover on reinforcement shall be 1" (25mm) minimum, unless otherwise indicated on the drawings.

2.2.3 Steel Plates:

Steel plates shall be fabricated from A-283 steel plate material and bent in accordance with the drawings. Headed anchors shall be Nelson stud anchors (or approved equal), and shall be of the size and quantity indicated on the drawings. Headed anchors shall be welded to the bent steel plates in accordance with the anchor manufacturer’s recommendations. Steel plates shall be placed in the arch form prior to casting the arch segments and securely held in the proper position during the casting operation.

2.2.4 Casting:

Place concrete in arch unit without interruption and consolidate by use of an approved vibrator, supplemented by such hand-tamping as may be necessary to force the concrete into the corners of the forms. Formation of stone pockets or cleavage planes shall be prevented. Clear form oil from the same manufacturer shall be used throughout the casting operation. Lifting devices shall be set in place to the dimensions and tolerances shown on the drawings prior to casting.

2.2.5 Curing

Cure precast arch segments for a sufficient length of time so that the concrete will develop the specified compressive strength. Any production lot which does not conform to the strength requirements of Section 2.2.9 shall be rejected.

2.2.6 Removal of Forms

Maintain forms in place until concrete has cured to a suitable strength that will allow elements to be safely removed without damage.

2.2.7 Concrete Finish

The inside face of all arch elements shall have a smooth gray consistent finish. Consistency of finish shall be maintained with the use of the same concrete mix and same type of form oil for the entire project. The side edge(s) of the element shall have an unformed surface finish, trowelled with no open pockets or distortions in excess of 3/16" (5mm).

2.2.8 Allowable Tolerances

Manufacture all units within the following tolerances:

Chords and Diagonals

Dim. > than or = to		Arch Segment Tolerance	Average Lot tolerance
> than or = to	and < than		
0 ft	15.75 ft	± 3/16" (5mm)	± 3/16" (5mm)
15.75 ft(4.8m)	31.5 ft	±5/16"(8mm)	± 3/16"(5mm)
31.5 ft (9.6m)	47.25 ft	±1/2"(12mm)	± 1/4"(6mm)
47.25' (14.4m)	Larger	±3/4"(20mm)	± 3/8"(10mm)

1. TechSpan Element Width : +3/16" to -3/16" (+ 5mm to -5mm)

2. TechSpan Element Thickness: +9/16" to -3/16" (15mm to -5mm)

3. Arch Surface Finish: Surface defects on smooth formed surfaces of the precast arch section measured with a straight edge over a 4 ft (200mm) length shall not exceed 3/16" (5mm).

4. The average lot tolerance shall be rendered as an overall quality control check for comparison of arch segments cast within the same project.

2.2.9 Compressive Strength

1. Acceptance of the precast concrete arch elements, with respect to compressive strength, will be determined on the basis of production lots.

   a. A production lot is defined as a group of precast concrete arch segments that will be represented by a single compressive strength sample and will consist of either eight arch elements or a single day's production, whichever is less.

2. During production of the precast concrete arch segments, the manufacturer will randomly sample the concrete in accordance with AASHTO T-141.

   a. A single compressive strength sample, consisting of a minimum of four cylinders, will be randomly selected for every production lot.

3. Cylinders for compressive strength testing shall be prepared in accordance with ASTM C31 (Dimensions: 2 x Diameter = Height). For every compressive strength sample, a minimum of two cylinders shall be cured in the same manner as the arch segments and tested at approximately seven (7) days. The average compressive strength of these cylinders, when tested in accordance with ASTM C39, will provide a test result which will determine the initial strength of the concrete. In addition, two cylinders shall be cured in accord with ASTM C31 and tested at 28 days. The average compressive strength of these two cylinders, when tested in accordance with ASTM C39, will provide a compressive strength test result which will determine the compressive strength of the production lot.

4. If the initial strength test result indicates a compressive strength in excess of 4,000 psi (27.6 MPa), then that initial test result may be considered the compressive strength test for that production lot, and the requirement for further testing at 28 days may be waived for that same production lot. [Note: It may still be desireable to perform strength tests at 28 days to meet the requirements of production lot acceptance under Item 5]

5. Acceptance of a production lot will be made if the compressive strength test results is equal to or greater than 4000 psi (27.6 MPa). If the compressive strength test result is less than 4,000 (27.6 MPa) psi, the acceptance of the production lot will be based upon its meeting the following acceptance criteria in its entirety:

   a. 90% percent of the compressive strength test result for all production lots shall exceed 4,150 psi (28.6 MPa).

   b. The average of any six consecutive compressive strength test result shall exceed 4,250 psi (29.3 MPa).

c. No individual compressive strength test result shall fall below 3,600 psi (24.8 MPa).

6. In the event a production lot fails to meet the specified compressive strength requirements, the elements from the production lot shall be rejected. Such rejection shall prevail unless the manufacturer, at his own expense, obtains and submits evidence of a type acceptable to the Owner's Engineer that the strength and quality of the concrete placed within the elements of the production lot is acceptable.

   a. If such evidence consists of tests made on cores taken from the precast concrete arch segments within the production lot, the cores shall be obtained and tested in accordance with AASHTO T-24.

2.2.10 Repairs at Fabrication Facility

1. It is recognized that certain cracks and surface defects may not be detrimental to the structural integrity of the arch unit and may be harmless if remedied by proper repair.

2. Before shipment, surfaces of all precast arch units shall be examined. The RECO Project Manager (PM) will determine the kind, type and extent of cracks and surface defects, such as honeycomb and chipped edges or corners that may be repaired. All such cracks and surface defects shall be repaired in a manner satisfactory to the PM.

3. If the PM determines that defective concrete unit(s) cannot be repaired properly and satisfactorily, the unit(s) shall be rejected.

2.2.11 Marking

The date of manufacture, the production lot number, and the piece-mark shall be clearly inscribed on the unformed edge of each arch segment.

2.2.12 Handling, Storage and Shipping

Handle, store and ship units in such a manner as to eliminate the danger of chipping, cracking, and excessive bending stresses. Precast concrete arch segments in storage shall be properly placed on edge on firm blocking on level ground to avoid damage or warping.

2.3 IMPERMEABLE GEOMEMBRANE

Impermeable geomembrane shall be Bituthene 3000 membrane as manufactured by the W.R. Grace Company or equal as approved by The Reinforced Earth Company.

2.4 FLOWABLE GROUT

High fluidity, non-ferrous, non-shrink grout as manufactured by the Burke Company or approved equal by The Reinforced Earth Company, shall be used after erection to grout the TechSpan elements into the keyway or recess in the cast-in-place footing. Grout shall have a compressive strength of at

least 4,000 psi and shall meet Corps of Engineers CRD-C621-88 for all consistencies.

2.5 BACKFILL

2.5.1 Select Granular Backfill

All select granular backfill material used around the TechSpan precast arch system in Zones 1 and 2, as indicated on the drawings, shall be free from organic or otherwise deleterious materials. In addition, the select granular backfill material shall conform to the following requirements:

1. The backfill material shall conform to the following gradation limits in accordance with AASHTO T-27.

Sieve Size	Percent Passing
3 inches (76mm)	100
3/4 inches (19 mm)	20-100
No. 40 (0.425 mm)	0-60
No.200 (0.075 mm)	0-15

2. The material shall exhibit an angle of internal friction of not less than 34 degrees as determined by the standard direct shear test - AASHTO T-236, utilizing a sample of the material compacted to 95 percent of AASHTO T-99 Methods C or D (with oversize correction as outlined in Note 7) at optimum moisture content.

3. The material shall be substantially free of shale or other soft or poor durability particles. The material shall exhibit magnesium sulfate soundness loss of less than 30 percent after four (4) cycles in accordance with AASHTO T-104.

4. Backfill not conforming to these specifications shall not be used without the written consent of RECO.

5. The Contractor shall provide the Owner’s Engineer with a certificate of compliance certifying that the select granular backfill material complies with this section of the specifications. A copy of all test results performed by the contractor, which are necessary to assure compliance with the specification, shall also be furnished to the Owner’s Engineer.

6. The frequency of sampling of select granular backfill, necessary to assure gradation control throughout construction, shall be as directed by the Owner’s Engineer.

2.5.2 Embankment Fill Material

Embankment fill (Zone 3) used outside of the select granular backfill volume (Zones 1 and 2) shall exhibit an angle of internal friction of not less than 30 degrees. Embankment fill not conforming to this requirement shall not be used without the written consent of RECO.

3 EXECUTION

3.1 GENERAL

The precast concrete arch structure shall be constructed in accordance with the lines, grades, details and dimensions shown on the drawings. The Contractor shall make use of the technical assistance provided by the supplier and provide adequate notice to the supplier of the date for start of arch erection.

3.2 PRECAST CONCRETE ARCH SEGMENT

3.2.1 Off-loading, handling, storage, and pre-assembly

When precast concrete arch segments (or elements) are off-loaded and stored, they shall be placed on edge upon secured dunnage on a level surface to avoid damage and warping, and to maintain cleanliness of the element prior to erection.

3.2.2 Erection of Precast Concrete Arch Segments:

1. Precast concrete segments shall be handled with a crane with a suitable capacity to safely handle the arch elements. TechSpan elements shall be lifted using inserts placed in the elements for that purpose.

2. Erect elements in sequence as shown on the drawings. When foundation is sloped, erection should begin at the low end of the structure and proceed in the up-slope direction.

3. Place segments tight against the front edge of the "recess" in the cast-in-place footing with the aid of wedging from the back of the segments. Longitudinally, joints between adjacent segments shall not exceed 3/4" (19 mm). The edge of the element on one side of the arch structure shall be placed to within 3/8" (10mm) from the centerline of the last element placed on the opposite side. Adjust element locations longitudinally to achieve consistent joint spacing.

4. Secure connecting wires between adjacent elements progressively as the placement of the arch segments advances. Place impermeable membrane over the joints using adhesive.

5. The final position of the installed arch segments shall clear both horizontally and vertically the span and height requirements of the tunnel.

3.3 GROUTING

Grout the TechSpan elements into the cast-in-place footing keyway recess after the arch is completely installed (on both sides) but prior to backfilling. Grout shall be cured in a manner sufficient to achieve specified strength.

3.4 CROWN BEAM

3.4.1 Concrete for the Cast-in-Place Crown Beam

Concrete for the cast-in-place crown beam shall have a minimum 28 day compressive strength of 4,000 psi (27.6 MPa).

3.4.2 Steel Reinforcing Bars

Steel reinforcing bars shall be ASTM A615, 60,000 psi (414 MPa) minimum yield strength.

3.4.3 Cast-in-Place Crown Beam

The cast-in-place crown beam shall be formed to the dimensions shown in the drawings when granular backfill has reached the top of the assembled arch units.

3.4.4 Styrofoam Spacers

Styrofoam spacers shall be incorporated into the crown beam as indicated by the drawings.

3.4.5 Construction Joints

Construction joints in the cast-in-place crown beam shall be approved by the Engineer.

3.5 BACKFILL PLACEMENT

3.5.1 Commencing Backfilling

Do not commence backfilling until grouting of the footing keyway recess has been completed and cured as specified. In addition, backfill shall not proceed above the top of arch until casting of the crown beam has been completed and cured as specified.

3.5.2 Backfilling of TechSpan Structures

Backfilling of TechSpan structures must be performed in coordination with the erection and backfilling of the collar wall and wing walls as indicated on the drawings.

3.5.3 Placment of Backfill

Place approved backfill material in maximum 10"(250mm) compacted lifts unless otherwise specified. At no time during backfilling of the TechSpan structure should the differential level between opposite sides of the TechSpan structure exceed 20"(500mm).

3.5.4 Compaction Zones

TechSpan structures require three compaction zones, as shown on the drawings and described in the following table.

ZONE	RANGE LOCATION	COMPACTION	EQUIP. TYPE
1	0.0 - 1.5 ft (0 - 450mm) measured from backface of TechSpan element.	None	None
2	1.5 ft - 3.0 ft (450 - 900 mm) measured from back face of TechSpan element.	95% Standard Proctor per AASHTO T-99	Light walk behind compactor
3	> 3.0 ft (1000 mm) horizontally from backface of TechSpan element at footing. > 3.0 ft (1000 mm) vertically above crown of TechSpan	95% Standard Proctor per AASHTO T-99	Large drum roller (with vibration)

3.5.5 Grading

At the end of each day, the backfill must be graded or sloped away from the back of the TechSpan segment to divert any run-off away from the work area.

3.5.6 Heavy equipment

Trucks and heavy equipment should not come closer than 5 ft (1500 mm) of the concrete TechSpan segments during any stage of backfilling, and must not traverse the longitudinal axis of the structure until a minimum of 3 ft (1000 mm) of fill has been placed above the arch crown. A further determination of maintained distances from the arch structure shall be made by the Contractor and Owner’s Engineer on the basis of the type of trucks or other narrow wheel-based equipment planned for use during backfill operations.

4 METHOD OF MEASUREMENT AND PAYMENT

4.1 TECHSPAN ARCH

4.1.1 Unit of Measurement

The unit of measurement for furnishing and fabricating all materials for the arch, including precast concrete, impermeable geomembrane, and incidentals shall be the lineal foot of TechSpan arch measured along the centerline of the arch tunnel. The arch length shall include the nominal arch segment joint opening.

4.1.2 Quantity to be Paid

The quantity to be paid-for shall be measured on the basis of arch tunnel supplied. The beginning and ending stations of TechSpan arch, as shown on the drawings, shall be used to determine the arch tunnel length.

4.2 ARCH ERECTION

The unit of measurement for arch erection shall be the linear foot (linear meter) of arch tunnel complete and in place. The quantity to be paid for shall be the actual quantity erected in place at the site as determined by Section 4.1.1. Payment shall include compensation for all labor, materials and equipment required to erect the precast concrete arch segments to the lines and grade shown on the drawings, place and connect the arch crown materials, grout the arch footing recess, and install the impermeable geomembrane.

4.3 BACKFILL

Measurement and payment for backfill performed during the TechSpan arch construction shall be in accordance with the applicable portions of the contract documents.